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Residential Sector Energy Demand and Analysis of Resunga Municipality, Gulmi, Nepal

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Abstract
This paper focuses on the research relating to Residential Consumption. Primary data required for the research is obtained through survey. For the calculation of energy of base year and projection LEAP is used. From the survey it is found that the major supply is from firewood and LPG which contributes 149.52 TJ/yr, i.e. 78.75 % and 29.95 TJ/yr, i.e. 15.775% of total energy respectively. The electricity,kerosene contributes 4.741%, 0.385% respectively and other remaining sources provide 0.349%. Out of 189.86 TJ consumed in year 2016, cooking consumes 116.3 TJ i.e 61.26% of total energy. The study also proposes some scenario to help reduce the energy consumption. One such scenario is ICS substitution and awareness program which will result in 9.7 TJ of energy saved in year 2030 by the reduction in quantity of fuel-wood used in cooking/heating process. With efficient lighting scenario the energy consumption in year 2030 will be 191.43 TJ compared to 192.5 TJ in reference scenario which results in saving of 1070 GJ of energy.

Keywords
LEAP: Long Range Energy Alternatives Planning – CBS: Central Bureau of Statistics–WH: Water Heating–AFM: Animal Food Making–TJ: Tera Joule

1. Introduction

Energy is the vital element for sustainable development of country. Energy resources are regarded as the key strategic natural resources having the potential to be the catalyst for all round development and economic growth of the country.Unless the energy sector is geared up for efficient and indigenous sustainable resources along with their sustainable harnessing, economy cannot move forward on a higher growth path. Every advanced economy requires secure access to modern sources of energy to fortify its development and growing prosperity. Access to reliable and affordable energy services is fundamental to reducing poverty and improving health, increasing productivity, enhancing competitiveness and promoting economic growth.

1.1 Problem Statement

In year 2008/09 total energy consumption was 401 million GJ of which 89.1 % is consumed by residential sector which amounts to 356.7 million GJ[1]. Hence being the highest energy consuming sector there has been some researches done on residential sectors of our country but the studies are either for a whole country or of the kathmandu valley in most cases, leaving the studies regarding the energy production and consumption of areas outside the valley at scarce. This research focuses on Resunga Municipality situated in Gulmi district.

1.2 Objectives

The primary objective of this thesis research is to find out the current residential energy profile and projection of energy demand.

2. Literature Review

2.1 Brief Description of Resunga

Resunga Municipality is a Municipality situated in Gulmi District, Nepal. The municipality was established by the government on 18 May 2014 by

merging the existing 4 village development committee i.e. Arkhale, Dubichaur, Simichaur and Tamghas. The municipality is named after the holy place Resunga in Gulmi District. There were 7448 households and 28736 people residing on Resunga Municipality [2].

2.2 Papers on Similar field

These are some research papers on the similar field. In paper National Energy Demand Projections and Analysis of Nepal, sector wise nation's energy demand model is developed and available energy consumption information of country is taken.[3] "Commercial Sector Energy Demand Projections of Nepal for Sustainable Sectoral Energy Planning", four different growth scenarios are considered and LEAP framework is used citeCSEDPAN.

"Industrial Sector's Energy Demand Projections and Analysis of Nepal for Sustainable National Energy Planning Process of the Country", projects industrial demand [4]. "Energy Demand Analysis of Five & Four Star Hotels in Kathmandu Valley", energy saving that can be achieved through energy saving measures in hotel is shown [5]. "Energy Consumption and Scenario Analysis of Residential Sector Using Optimization Model – A Case of Kathmandu Valley", Residential energy system has been developed using MAED and MARKAL and evaluated using least cost optimization method using ANSWER MARKAL for various scenarios [6]. "Current Energy Consumption in Bhaktapur District", current energy scenario of Bhaktapur district is analyzed by use of primary data obtained through survey [7].

2.3 End Use Demand

From the review of prior studies and reports, it was found that there are six main end-uses viz. cooking, lighting, water heating and animal food making, space heating and space cooling. Electric Appliances include TV, radio, fridge, water pump, etc. An extra section Other is added which presents the extra uses on the similar tasks but beside the normal or daily use.

3. Research Methodology

Research methodology follows commonly followed steps in research. It consists of literature review,area of research and gap identification, sample size calculation for the area, questionnaire development, primary/secondary data collection, primary calculation, development of LEAP model and analysis and final reporting.

3.1 Study Area

Resunga Municipality of Gulmi District is taken as study area. The primary reason being the research focused on area beside the Kathmandu valley.

3.2 Sample Size Calculation

The Sample size for the research is found to be 366 by using the standard formula used by [8].

3.3 LEAP Model

LEAP is used for the energy demand and analysis. The calculation of Energy Demand will be done as:

$$\text{Energy Demand} = \text{Energy Intensity} \times \text{Activity Level}$$

Energy intensity is the energy used per households and activity level is the percentage of houses using that type of energy.

In the model the increase in demand is associated with the numbers of household and households increase rate is proportional to increase in population.

4. Results and Discussion

From the survey it is found that a total of 189.86 TJ of energy is consumed per year in Resunga Municipality. As expected fuelwood is the highest contributor among all even though the usage is in decreasing amount. A household was found to consume 1345 kg of Fuelwood per year. LPG follows the Fuelwood in terms of energy utilized/consumed. The LPG per household was found to be approx. 6.6 cylinders/household. Electricity is third highest. Most of the houses were found to consume minimum electric amount monthly that is 20 kWh. Other remaining households electricity consumption span in the range 20-160 kWh for domestic users. The average electricity consumption of resunga Area is 27.5 kWh per household per month.

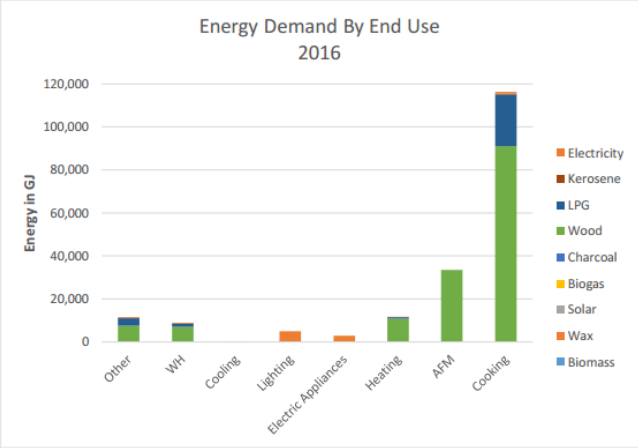

Figure 1: Energy Consumption in Resunga

It is evident from figure 1 that cooking takes up the highest energy consuming position among all other uses. Animal food making (AFM) and Water Heating (WH) are second and third highest in consumption followed by heating . It can be seen that bulk of the energy is from the fuelwood in each usage category. LPG is second to fuelwood in cooking and some other uses too.

Table 1 presents the amount of energy from different fuels in year 2016.

Table 1: Energy Demand of different fuels

Fuels	Other	WH	Cooling	Lighting	Electric Appliances	Heating	AFM	Cooking
Biomass	33.9	-	-	-	-	75.2	-	138.8
Wax	-	-	-	7.5	-	-	-	-
Solar	-	-	-	232.2	-	-	-	-
Biogas	-	-	-	-	-	-	-	9.0
Charcoal	27.6	-	-	-	-	133.3	-	6.3
Wood	7,497.6	7,022.7	-	-	-	10,638.8	33,463.9	90,893.0
LPG	3,519.2	1,561.0	-	-	-	751.0	-	24,119.2
Kerosene	343.5	8.6	-	94.2	-	-	-	284.4
Electricity	59.7	399.6	0.2	4,668.6	2,951.0	56.1	-	866.4
Total	11,481.5	8,991.9	0.2	5,002.6	2,951.0	11,654.4	33,463.9	116,317.1

The pie-chart in figure 2 shows the total sharing of energy among different resources. It was found that fuelwood and LPG contributes 149.52 TJ/yr, i.e. 78.75 % and 29.95 TJ/yr, i.e. 15.775% of total energy respectively. The electricity,kerosene contributes 4.741%, 0.385% respectively and remaining 0.349% by other sources.

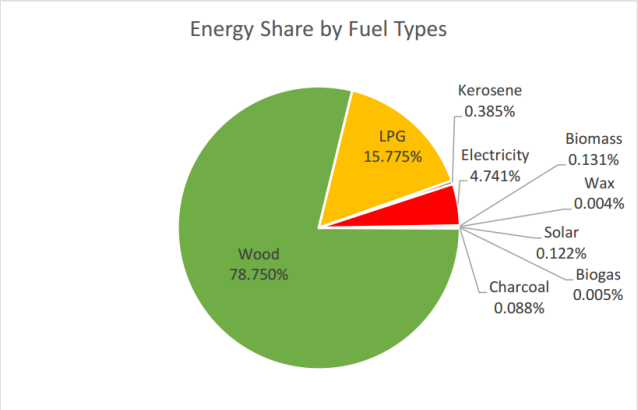

Figure 2: Total Share of Energy

4.1 Scenario

Different Scenario like reference scenario, ICS substitution, Efficient lighting are proposed in the research study.

4.1.1 Reference Scenario

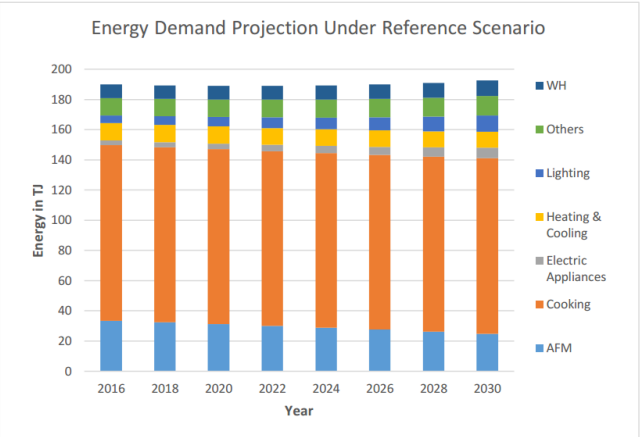

Figure 3: Energy Projection

The figure above shows the energy demand projection upto year 2030 in reference scenario. From the projection it was found that the energy in year 2016, 189.86 TJ increases to 192.5 TJ in year 2030. Cooking requirement changes from 116.32 TJ to 115.29 TJ. The decrease in cooking energy requirement is because of the shift from fuelwood to LPG and use of ICS for cooking. Similarly other end use demand upto year 2030 can be seen from the table below:

Table 2: Energy Projection

Energy in TJ	2016	2018	2020	2022	2024	2026	2028	2030
AFM	33.46	32.42	31.32	30.16	28.94	27.66	26.31	24.89
Cooking	116.32	115.99	115.74	115.58	115.53	115.61	115.85	116.29
Cooling	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electric Appliances	2.95	3.32	3.74	4.21	4.75	5.35	6.03	6.80
Heating	11.65	11.48	11.31	11.14	10.98	10.82	10.66	10.52
Lighting	5.00	5.58	6.23	6.96	7.78	8.69	9.72	10.86
Others	11.48	11.53	11.62	11.74	11.91	12.14	12.44	12.82
WH	8.99	8.88	9.01	9.17	9.38	9.63	9.94	10.32
Total	189.86	189.21	188.97	188.97	189.26	189.90	190.95	192.50

4.1.2 ICS Scenario

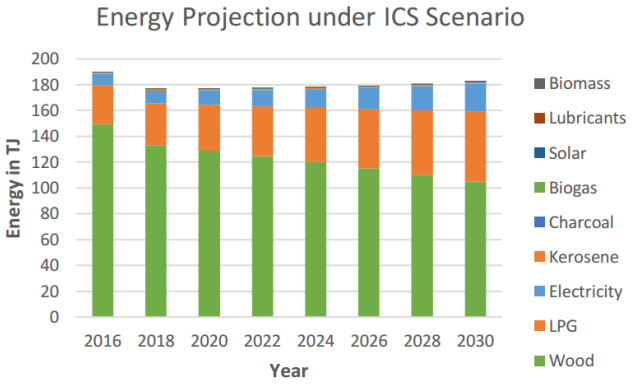

Figure 4: Energy Projection under ICS substitution

Figure 4 shows the projection of energy demand under ICS substitution scenario.There is an abrupt decrease in energy in year 2017 and 2018, the reason is that by the end of year 2016 every houses using fuelwood are supposed to have ICS . And by the end of year 2017 people are to be made aware of the reduction in fuelwood consumption by use of ICS thus ensuring the use of ICS in other activities like animal feed cooking and water heating. It was found that with ICS in implementation the cooking demand decreases from 116.32 TJ in year 2016 to 108.58 TJ. Hence by just focusing on reduction in cooking demand which is the highest consuming end use, there can be signigicant saving of energy.

4.1.3 Efficient Lighting Scenario

Figure 5 shows the change in energy structure with the implication of efficient lighting scenario. Only energy used for lighting is considered to clearly show the reduction in energy demand compared to reference Scenario.Reference Scenario is shown alongside the efficient lighting scenario for easy comparison. It can be seen from the figure that with efficient lighting scenario there is saving possibility and the saving is increasing by passing of year. In year 2030 there is a saving of 1.1 TJ of energy.

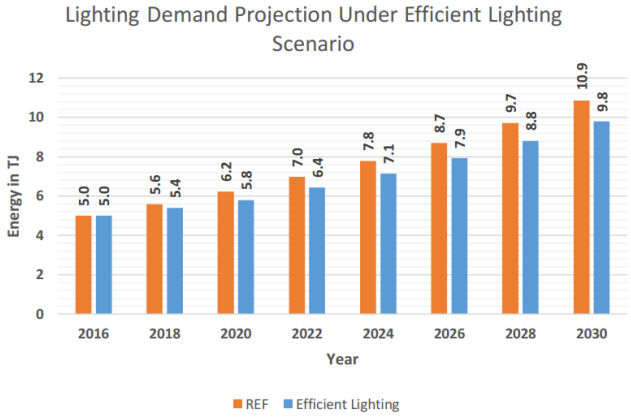

Figure 5: Energy Projection under efficient lighting

4.1.4 Combined Scenario

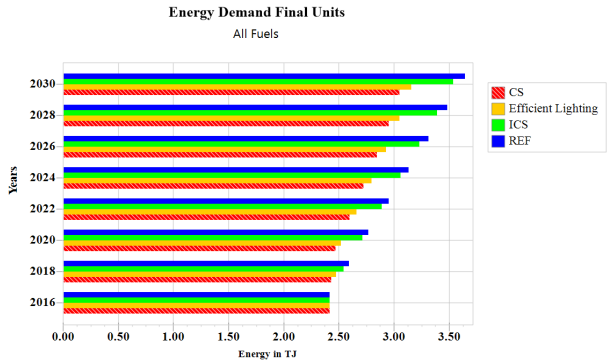

Figure 6: Energy Projection under different Scenario

Combined Scenario (CS) is the combination of both ICS substitution and Efficient lighting Scenario. The figure above shows all three scenario along with reference scenario. From the figure we can see that efficient lighting scenario energy demand is little lesser than the Reference Scenario. And with further decrease in energy demand by following ICS substitution. The energy requirement is projected to be 177.18 TJ in year 2020 and 182.8 TJ in year 2030 for ICS Scenario compared to 188.97 TJ and 192.5 TJ of energy in reference scenario. That is a saving of 9.7 TJ is possible just by implementing the ICS substitution work. With efficient lighting also in implementation the total energy demand in year 2030 reduces to 181.73 TJ. Hence a saving of 10.77 TJ of energy.

5. Limitation and Recommnedation

The research on Residential Sector of Resunga has number of limitations.Sample size is taken with confidence interval of 95% and error 5%. The research can be made more accurate if more sample size is taken. Apart from the residential sector one can include other sectors like commercial, transportation, etc. to make a more and comprehensive energy uses in an area. The appliances used in the households have different power rating but for ease of research process an average of standard value is taken in order to calculate the power consumed by such devices.

This research can further be upgraded by taking in detail status of equipment's rating used in households with longer span setup for survey. An experimental setup can be prepared in some houses measuring the quantity of fuel-wood and such other resources for a month or more for more accurate measurements.

Acknowledgments

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